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ORGANIZATION OF COMMUNICATION IN INFORMATION SYSTEMS

V. P. Datsenko, et al

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By: V. P. Datsenko and N. G. Zaytsev

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Block	Italic	Transliteration	Block	Italic	Transliteration
А а	*А а*	A, a	Р р	*Р р*	R, r
Б б	*Б б*	B, b	С с	*С с*	S, s
В в	*В в*	V, v	Т т	*Т т*	T, t
Г г	*Г г*	G, g	У у	*У у*	U, u
Д д	*Д д*	D, d	Ф ф	*Ф ф*	F, f
Е е	*Е е*	Ye, ye; E, e*	Х х	*Х х*	Kh, kh
Ж ж	*Ж ж*	Zh, zh	Ц ц	*Ц ц*	Ts, ts
З з	*З з*	Z, z	Ч ч	*Ч ч*	Ch, ch
И и	*И и*	I, i	Ш ш	*Ш ш*	Sh, sh
Й й	*Й й*	Y, y	Щ щ	*Щ щ*	Shch, shch
К к	*К к*	K, k	Ъ ъ	*Ъ ъ*	"
Л л	*Л л*	L, l	Ы ы	*Ы ы*	Y, y
М м	*М м*	M, m	Ь ь	*Ь ь*	'
Н н	*Н н*	N, n	Э э	*Э э*	E, e
О о	*О о*	O, o	Ю ю	*Ю ю*	Yu, yu
П п	*П п*	P, p	Я я	*Я я*	Ya, ya

* ye initially, after vowels, and after ъ, ь; e elsewhere. When written as ё in Russian, transliterate as yё or ё. The use of diacritical marks is preferred, but such marks may be omitted when expediency dictates.

ORGANIZATION OF COMMUNICATION IN
INFORMATION SYSTEMS

V. P. Datsenko and N. G. Zaytsev

In automated systems of information service developed on the basis of universal computers (general-purpose computers) and intended for automation of information work within the limits of one enterprise, it is very important to organize communication between the machine and the users (subscribers) of the system. It is necessary:

1) to select technical means of communication ensuring effective and convenient access of the subscribers to the system;

2) to determine the necessary composition of equipment on the basis of technico-economic analysis;

3) to calculate the volumes of a single type equipment depending on system load.

All these questions are considered in this article.

Technical Means and Structure of Organization of Communication

The block diagram of the organization of communication in the system is represented in Fig. 1, where [TF] (ТФ) is a telephone;

[TG] (ТГ) is a telegraph; [PVS] (ПВС) is a switch form of communication; [M] (М) is a modulator; [D] (Д) is a demodulator; [PI] (ПИ) is a preliminary selector; 1 [GIU] (ГИУ) is a first group, universal selector; [LI] (ЛИ) is a linear selector; [US] (УС) is a coupler; and [UVM] (УВМ) is a general-purpose computer.

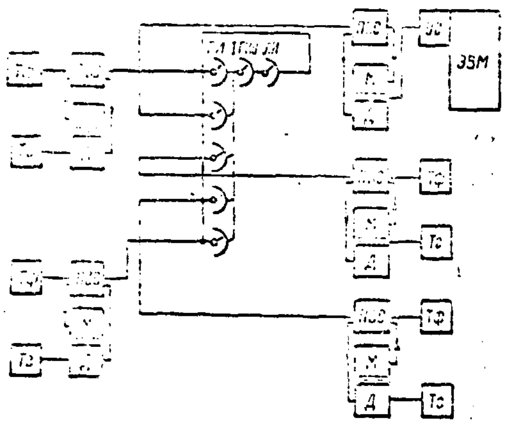

Fig. 1.

All this equipment, by assignment and place of installation can be expediently subdivided into three groups:

1) subscriber equipment;

2) switching equipment with lines of subscriber network;

3) computer equipment.

Subscriber equipment is set directly for the subscriber. This equipment must be habitual and convenient for the subscriber, fix information in a form acceptable for him (printed word-numerical test) and store (save) information if the communication channel or the subscriber himself is occupied.

The set requirements are satisfied by telegraph equipment, where fixation of information both during transmission and during reception is carried out in printed form. Information is transmitted in digital-code form, which permits introducing this information into the machine without special conversions. Telegraphs make it possible to store information on punched tapes.

As shown later, for connection of telegraph equipment with the general purpose computer it is economically most expedient to use equipment of a telephone network. Therefore, subscriber equipment consists of the following instruments: telegraph, telephone, a modulator-demodulator of tonal telegraphing, and a switch of the communication type.

The telegraph fulfills the function of information transmission. The telephone is mainly for usual telephone communication, and here is used only to connect the subscriber with the machine (or the machine with the subscriber). The modulator-demodulator provides passage of telegraph information over the telephone line. With a switch of the connection form the subscriber carries out either communication with the system, or usual telephone communication.

In accessing the system the subscriber with the help of a telephone disk, as in usual communication, establishes communication with computer equipment. After connection by a switch of the communication type are established conditions of transmission of telegraph information, and on the telegraph is printed the contents of the inquiry.

Switchboard equipment with lines of subscriber network. For communication of telegraph equipment with the machine it is necessary to have corresponding switching equipment and lines of subscriber network. Here are possible two variants:

1) installation of a subscriber telegraph station (ATA) and laying of corresponding cable ducts;

2) use for establishing communication of an institutional automatic exchange [ATS] (ATC) Automatic Telephone Station, with transmission of telegraph information through equipment of tonal telegraphing.

Concrete selection from these possible variant should be made on the basis of their technico-economic comparison. In the following paragraph such a comparison is made and it is shown that as switching equipment it is economically most expedient to use equipment of an institutional ATS. For organization of communication in information systems it should have the possibility of

1) organization of one-sided sign-off;

2) automatic transmission of signal about readiness of called subscriber (especially during automatic reception of an answer to the telegraph of the subscriber).

Series ATS for institutional communication, in general, do not satisfy these requirements; therefore, the corresponding insignificant changes must be introduced into them. For example, for an ATS of the UATS-49 type it is necessary to replace instrument [1GI] (1ГИ) and 1GIU (see point 2), to change the polarity of the feed voltage in the LI current, and to shunt the winding of the C-950 relay C in the 1GIU circuit (see point 1).

Computer equipment is in the immediate vicinity of the computer. During determination of the composition of this equipment it is necessary to take into consideration that two modes of establishing communication in the system are possible:

1) direct connection of subscriber with machine;

2) connection with delay through intermediate storage unit.

In the first mode the subscriber is connected directly with the machine for the whole time of its service (up to several minutes). Contemporary types of general purpose computer, for example the "Minsk-22" permit fulfilling a connection for which are required insignificant improvements in the machines. The examined mode of connection ensures the fastest satisfaction of the inquiry

of the subscriber; its deficiency is that the machine is occupied a long (from the point of view of computer operation) time, during which it cannot service other subscribers.

In the second mode information from subscribers goes to telegraph equipment of the machine, several of which can be established. Here it is fixed on punched tapes, from which it is introduced into the machine through an input photoreader at high speed. Results from the machine are issued also on punched tape through output punches which work at a speed several times the operating speed of the telegraphs punches of the PL-20 type are 3 times as fast, and of the PL-80 type are 12 times as fast. Information is transmitted to subscribers from the obtained punched tapes through the machine telegraphs, but manual operations with punched tapes should be fulfilled by the operator, although machine time is used in the very best manner.

In every concrete case the mode of connection must be selected taking into account the requirements of the subscriber as to the speed of processing of an inquiry.

Thus, in the machine is equipment including a unit coupling the telegraph channel with the machine in conditions of direct connection and sets of subscriber equipment, through which is carried out communication with subscribers in conditions of connection with delay. Selection of conditions of connection is determined by the fact that corresponding channels of inversion are given different telephone numbers.

For transmission of the answer from the machine to the subscriber their connection with each other is carried out in the following way. In conditions of direct connection, communication is established by the subscriber during transmission of the inquiry and is not interrupted prior to the obtaining of an answer. In conditions of connection with the operator the subscriber is called by the operator, after which the answer put out on punched tape is transmitted to it by the telegraph of the machine through

its automatic transmitter. During application of the device of automatic signalling of the subscriber via a code number on punched tape, information can be transmitted without the operator. Code numbers of subscribers are filled by the machine during output of the answer to punched tape.

An essential requirement for organization of communication in systems of information service is safeguard of the required level of authenticity of transmission of information. In the examined systems communication channels are used only for operational intercourse of the subscriber with the machine. Initial information in the form of documents is transmitted to the service of preparation of data of systems, and then is punched and introduced directly into the machine.

During operational inversion the length of both inquiries and answers is one, in extreme case several phrases, i.e., approximately 100-300 symbols are transmitted. It is possible to consider permissible distortion of 1% of transmitted inquiries since in the system, thanks to logic possibilities of the general purpose computer are provided methods of detection of distorted inquiries. Thus, during transmission of information the expected probability of short duration failures should be more than 10^{-4}.

The required reliability is ensured by the examined system of organization of communication. According to literary data [1] during the use for transmission of data of the city telephone network at a speed of telephoning of 300 data processing units and less, the expected probability of short duration failure is less than 10^{-4}. During the use of modulator-demodulators with frequency modulation at the central frequency of the channel of 3150 Hz [2] and at a speed of telegraphing of 50 data processing units according to G. P. Divnogortsev [1] the probability of appearance of short duration failure is still lower.

The examined scheme of organization of communication is carried out in the Institute of Cybernetics of the Academy of Sciences of

the Ukrainian SSR in the form of a mock-up of a coupling network into which enters one full set of subscriber equipment, equipment of the machine set and into which are introduced the necessary changes into the circuit of the ATS of the institute. During tests of the mock-up, corresponding to real conditions of work of the system, were transmitted about 1 million symbols. The number of incorrectly transmitted symbols was about $5 \cdot 10^{-5}$ of the whole volume of such signs. Failures in equipment operation were not observed.

Technico-Economic Foundation of Selection of Switching Equipment

During the carrying out of technico-economic selection of switching equipment it is necessary to be guided by the standard method of fulfillment of technico-economic calculations [3]. The criterion for selection of a concrete variant is the minimum of given expeditures $Z_{\text{пр}i}$:

$$Z_{\text{пр}\,i} = \frac{k_i}{T} + C_i \to \min. \qquad (1)$$

where k_i is capital expenditure according to the i-th variant in rubles or thousands of rubles; C_i is operational consumption according to the i-th variant in rubles or thousands of rubles in a year; T is the normative period of compensability of capital investments (for means of communication its value is taken as 6.6 years).

For brevity we will designate expenditures pertaining to variant ATA with index 1, and a variant ATS with index 2. It is senseless to consider identical components for both variant in the calculations.

Plants supply series stations of type ATA-57 with capacity from 20 to 100 numbers. However, with the use of these stations in formation systems it is possible to exclude from standard equipment the following: stand of adapters [PU] (ПУ), determinant of zones

[OZ] (ОЗ), computer [SU] (СУ), and also a certain number of commutators [ATR] (АТР) and stands [GI] (ГИ). Taking into account this circumstance are determined capital expenditures as a function of the number of subscribers. Results of calculations are represented on Fig. 2 (solid curve). At a number of subscribers under 10, data are taken in reference to station ATA-10/3, mass produced by industry.

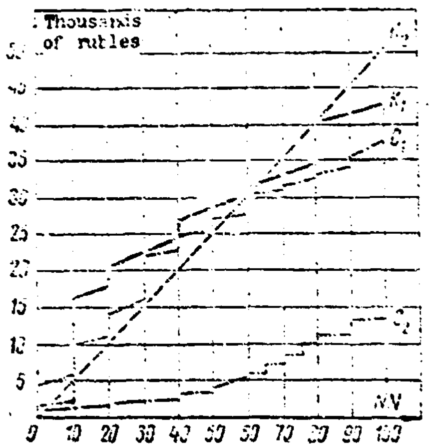

Fig. 2.

The character of the obtained curve is explained by the fact that capital expenditure can be considered to consist of two parts: constant and variable. The constant component includes the cost of the frame, stands, switching equipment in the volume necessary for the given capacity, power supplies, assembly works, etc. This component varies unevenly during transition from a station of one capacity to a station with another capacity, which explains breaks on the graph in points of change of capacity. To the variable component pertains the cost of equipment, set by the number of subscribers (calling instruments, instruments set on stands, etc.). The linear sections of the graph are caused by this component.

On Fig. 2 are reflected operational consumptions (according to the Ministry of Communications). Breaks on this curve are explained by discrete increase in the number of permanent personnel during transition to a station of higher capacity.

Organization of communication on the basis of an ATS is represented on Fig. 1. During determination of capital expenditures of this variant, we were guided by the following position. Use of an ATS for organization of communication in an information system, taking into consideration the speed of service of an individual subscriber by the information system, leads to increase in the load on the ATS during connection of every new information subscriber of 10-15% of the load of the usual subscriber of an ATS. The cost of additional switches is in this 10-15% and must be taken into consideration in capital expenditures of the examined variant. The number of modulator-demodulators of equipment of tonal telegraphing is proportional to the number of subscribers.

Thus, capital expenditures according to this variant are proportional to the number of subscribers of the information system and are represented by a straight line on Fig. 2. The cost of additional instruments to the ATS and the cost of modulator-demodulators of equipment of tonal telegraphing are taken from the calculation of plant-producers. Operational consumptions are determined from the cost of exploitation of additional equipment (see Fig. 2).

Given expenditures according to both variants are represented by a graph on Fig. 3. At all values of the number of connected subscribers, the minimum of given expenditures was apportioned to the variant with the use of an ATS. The difference between the given expenditures for variants is considerable. In spite of possible inaccuracies of calculations (especially due to the failure to take secondary factors into consideration), such difference permits with sufficient validity preferring the variant with the use of an ATS.

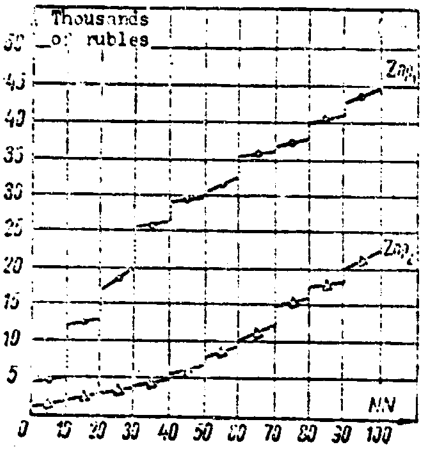

Fig. 3.

Determination of the Number of Subscribers and the Number of Channels of Access to the System

According to the character of its functioning, information systems are queueing systems; therefore, the number of subscribers and the number of channels of access to the system, determining quality of service, should be determined by methods of the queueing theory [4].

On Fig. 4 is schematically represented a system of information service from the point of view of this theory. Service requirements from subscribers, forming flow, enter the storage unit, which in general is one of the types of intermediate storage, where information about the requirement is stored until it is processed. From the storage unit the requirement in order of turn proceeds for processing to the general purpose computer. Obtained results are stored in output storage whence they are transmitted to subscribers. Thus, the information system consists of two queueing steps: 1) subscriber-machine; 2) machine-subscribers.

During organization of communication examined in the work, as a storage unit is used a punched tape, and information about requirements is transmitted over the telephone line of the ATS.

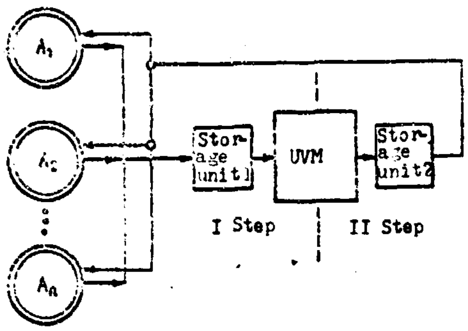

Fig. 4.

Thus, the "subscribers-machine" step is two-phase. The first phase – transmission of information to the storage unit – uses a telephone network and by virtue of this presents a system of service with losses. The second phase of this step and the second step are systems of service with expectation. Thus, the information system is a two-stage two-phase queueing system.

Let us consider a system working in conditions of connection of subscriber with the general purpose computer through the storage unit. Systems with direct connection of the subscriber with the machine are single-phase queueing systems with losses. Determination of parameters of service in such systems does not present special difficulties, since calculation formulas for them are known.

In systems can also be used simultaneously both conditions of connection, but up to now there is no method of calculation of such cases.

During development of the system in the first place it is necessary to determine the following indices:

1) the number of subscribers which can be included in the system; it depends on the carrying capacity of the machine, which, in turn, depends on the type of service; furthermore, the number of subscribers is influenced by the quality of service accepted in the system of parameters;

2) the number of channels of communication with the corresponding equipment, of the machine which are set aside for connection of subscribers with the general purpose computer; it, of course, should be limited, but at the same time the acceptable time of access to the system should be ensured.

The values of both indices are interconnected, which creates difficulty for their direct calculation. On the stage of development of the system these indices can be determined approximately. We assume that the number of communication channels is not limited; then one can determine the number of subscribers connected to the system. Having obtained this value and pursuing the index of quality of service, we determine the necessary number of communication channels. The obtained indices are approximate; however, on the level of development of the system they can be satisfied.

It is necessary to take into consideration that the total time of service $T_{\text{обсл.}}$ (exactly this time interests the subscriber) is composed of four components:

$$T_{\text{обсл.}} = T_{\text{зап.}} + \tau + T_{\text{обс.}} + T_{\text{от.}}, \tag{2}$$

where $T_{\text{зап.}}$ is the duration of transmission of information about the requirement; τ is waiting time; $T_{\text{обс.}}$ is time of service; $T_{\text{от.}}$ is duration of transmission of answer.

During accepted assumption about absence of limitations with respect to communication the number of subscribers depends only on the value of τ. Assignment of this value is determined by the normative value of $T_{\text{обсл.}}$

Making the usual assumptions with respect to flux distribution of requirement (Poisson) and time of service (exponential) the number of subscribers of the information system interesting us can be obtained on the basis of analysis of the following formula [4].

$$p(t>\tau)=\frac{m}{M}e^{-(M-m)\tau}, \quad (3)$$

where $p(t>\tau)$ is the probability of expectation over the assigned period; m is the average number of requirements entering the system in a unit of time; M is the average number of requirements serviced by the system in a unit of time; it characterizes the carrying capacity of the machine; τ is the assigned waiting time.

The waiting time, taking into account the above and the probability of the fact that which the real waiting time will exceed the assigned waiting time, are normative values and are assigned proceeding from the necessary speed of servicing of subscribers by the system. The value of $p(t>\tau)$ can usually be taken as 0.05, which means that five requirements out of 100 will be serviced in a time exceeding the assigned time. Such a condition is acceptable to us. Regarding waiting time τ, its permissible values can vary from several minutes to several tens of minutes. The concrete value of this value is assigned depending upon the real requirements for service in the system.

The number of requirements serviced by the system in a unit of time is determined by the parameters of the computer and the character of requirements being serviced. Series computers produced by industry have a speed of work of the order of several thousand operations per second and use magnetic tape storage [NML] (НМЛ) for storage of all basic information. The time of processing of the requirement $T_{\text{обс}}$ is composed of two basic components: access time of information from magnetic tape storage $T_{\text{нмл}}$ and processing time $T_{\text{сч}}$ (it is implied that input time of assignment and readout are values noticeably less than these components).

In the examined information systems the basic mass of time is occupied by access to the NML - component $T_{\text{нмл}}$. The number of accesses, depending on the volume of information blocks can reach tens and hundreds of accesses. The time of every access is the value from fractions of a second to several seconds. Thus, accessing the

NML takes approximately a minute to several minutes. The range of the number of requirements serviced by a system of the information type can be determined on the basis of these tentative data.

On Fig. 5 is given a nomograph plotted in accordance with formula (3), which allows determining the permissible intensity of entering flux with various assigned of expectation and with a normative value of probabiltiy of expectation over the assigned period, taken as 0.05. The range of change of values M and *m* is taken in accordance with tentative data substantiated above. Let us note that their proximity affects only the selection of the region of plotting of the nomograph, which one way or another is taken in sufficiently arbitrary limits; the value of *m* is determined accurately from the nomograph.

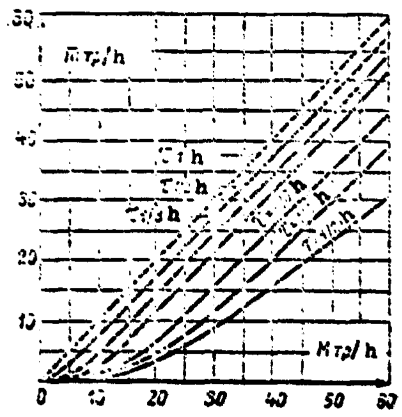

Fig. 5.

Designation: тр = tr = requirements.

Analysis of the given nomograph shows that at the assigned carrying capacity of the machine, the intensity of entering flow varies over wide limits depending upon waiting time. With increase in waiting time, starting with $\tau = 30$ min, intensity of entering flow increases considerably. Thus, the intensity of entering flow strongly varies from assigned waiting time only for systems with high speed of service. If, however, a waiting time of approximately 1 hour and more is allowed, then the intensity of entering flow approaches the carrying capacity of the machine. In the limit at infinitely large waiting time they are equal, which corresponds to the dotted line on the nomograph.

Knowing the permissible intensity of entering flow and the average number of requirements going out from one subscriber in a unit of time s, one can determine the maximum number of subscribers serviced by system N:

$$N = \frac{m}{s}. \tag{4}$$

The number of channels of access to the system C is the number of channels between the machine and commutational equipment for transmission of information about the requirement and the ready machine answer. The number of channels determines the volume of equipment of the machine. Since this phase of the service system is a system with losses, it is necessary to determine the number of channels of access at the assigned subscriber load and the assigned norm of losses.

The subscriber load of access channels A is determined by the formula

$$A = m(T_{\text{сp.}} + T_{\text{от.}}). \tag{5}$$

Knowing the value of A, the number of channels can be determined from Erlang [sic] tables. Let us give this table for norm losses equal to 0.05.

A Erlang	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3,74	[illegible]	5,37	[illegible]
C	1	2	3	4	5	6	7	8	9	10

For example, permissible waiting time is equal to 10 min; the average number of requirements serviced by the system in 1 h is equal to 30; each subscriber accesses the system on an average of one per hour (s = 1). On the nomograph we find the permissible intensity of entering flow m = 16 and by formula (4) we determine the maximum number of subscribers of the system N = 16.

For determination of the volume of equipment of the machine we will assume that $T_{\text{пер.}}+T_{\text{от.}}$ = 2 min = 1/30 h, then we will obtain the following value of C:

$$A = 16 \cdot \frac{1}{30} = 0.53 \text{ erlang.}$$

From the tables C = 3. This means that it is necessary to organize three communication channels of the general purpose computer with an ATS with three sets of subscriber equipment.

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ABSTRACT

(U) Organization of communications between the center of an automated system of information exchange and the subscribers to the system is described. There are three requirements. First, those technical communication means must be chosen which will provide effective and convenient avenues for calls from the subscribers to the center; second, the required equipment system must be determined on the basis of a technical and economical analysis; third, the amount of equipment of a single type must be computed depending on the system load. These three problems are considered in this article. The structural system for organizing this type of communication includes several devices which fall into three classifications: subscriber equipment, switching equipment for the subscriber nets, and computer equipment. A block diagram of the equipment involved and their interconnection is given. While the article is not highly mathematical, several formulas are presented: one for determining the number of subscribers that can be serviced by the system, another for determining the subscriber load for subscriber call channels. Orig. art. has: 5 figures, 5 formulas, 1 table.